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THE UNIVERSITY OF ALBERTA

A STOCHASTIC MODEL OF FAMILY PLANNING

by

© MICHAEL DAVID BRACHER

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTER OF ARTS

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THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled A STOCHASTIC MODEL OF FAMILY PLANNING submitted by Michael David Bracher in partial fulfilment of the requirements for the degree of Master of Arts.

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ABSTRACT

This study examines patterns of family planning among members of a sample of 689 Edmonton couples. The data are drawn from the Growth of the Alberta Families Study which, during the period November 1973 to February 1974, interviewed a total of 1,045 Edmonton women about their reproductive behaviour.

Preliminary analysis reveals that socio-economic and cultural factors, such as ethnicity, income and education, have little or no direct effect on the extent of current contraceptive use. Use of contraception, though widespread in Edmonton, does show a strong relation to the stage of family formation a couple has reached. This is especially true for the two most widely used techniques - oral anovulents and contraceptive sterilization - where an overwhelming popularity of the pill among low parity couples declines sharply in favour of sterilization among couples at parities two and above.

Subsequently, an absorbing Markov chain model is employed to study the implications for family-building in Edmonton if the patterns of family planning observed in the recent past were to continue unchanged. Whereas the majority of couples at all parity levels would be expected to continue employing temporary contraception systematically to regulate fertility, individual variations in both the use of temporary birth control methods and the timing and spacing of births are pronounced. Depite diverse strategies of family formation, however, most couples would ultimately adopt sterilization to achieve the goal of small completed family size.

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CHAPTER I

INTRODUCTION

> The persistence of . . . [anti-natalist folk practices suggests] . . . that the human race has in all ages and in all geographical locations desired to control its own fertility; that while women have always wanted babies, they have wanted them when they wanted them. And they have wanted neither too few nor to many . . . .
>
> What is new is not the desire for prevention, but effective, harmless means of achieving it on a grand scale. The older effective techniques were never until recently democratically diffused; and even that process is still going on.
>
> (Himes, 1963: 185)

Fragmentary knowledge of contraceptive techniques has existed in most societies throughout history. But, in traditional societies such knowledge, based often as not on folk medicine or ritual, has generally proved unreliable. Even where rational, effective means of fertility control have existed, knowledge of them has been confined until recent times to a relatively small and privileged segment of the population. (For discussions of fertility control in both traditional and transitional societies, see Lorimer, 1954.)

The last one-hundred-and-fifty years have witnessed the development of a multiplicity of reasonably effective methods of birth control. Notwithstanding technological advances, the diffusion of contraceptive knowledge among all social classes of Western Europe and North America remains the most important and new aspect of birth control since the middle of the nineteenth-century.

The roots of the family planning movement can be traced to the early British neo-Malthusians. Francis Place, writing in England

in the 1820's, viewed contraception as a substitute for the "moral restraint" (or, postponement of marriage without ex-nuptial sexual relations) that Malthus had advanced as the principal preventive check to rapid increases in human population. Later proponents of birth control, notably Knowlton and Sanger in the United States and Bradlaugh and Besant in the United Kingdom, tended to stress the desirability of family planning for the individual rather than for society as a whole. At a practical level, the leaders of the nineteenth-century birth control movement attempted to teach the value of rational family planning and to foster the use of contraception among all social classes. Their success is apparent; for, despite vitriolic opposition from legislative, ecclesiastical and medical bodies, awareness of the benefits as well as methods of birth control had become widespread in the West by the early decades of the present century (Himes, 1963: 209-285).

The experience of the nineteenth-century family planning movement suggests that any study of contraceptive practices must focus not on government policy but on the behaviour of individuals or, perhaps, of members of social classes. Even if birth control information is readily available and the actual methods not illegal, the effectiveness of any family planning regimen rests ultimately on the motivations and actions of individuals.

Previous Research Findings

Contraceptive techniques and practices have been investigated in a variety of demographic and medical studies. Given the nature of the subject, this research has typically been conducted within the

framework of specialized fertility surveys or in clinical situations. Although a complete review of the literature on birth control is beyond the scope of this thesis, it may prove instructive to summarize some of the principal findings of previous North American studies of contraceptive practices.

Before continuing further, however, terminology should be clarified. The terms "fertility control", "family planning" and "birth control" will be used synonymously to denote voluntary attempts to limit births either temporarily to achieve a desired interval between successive births or permanently to prevent more births than desired. More restrictively, contraception refers exclusively to measures taken to prevent coitus from resulting in conception. Accordingly, certain anti-natalist practices, such as abortion, delayed marriage and infanticide, which historically have proved to be effective means of fertility control, will not be considered.

American Literature

American fertility studies have focused upon the role played by contraception in allowing couples to space pregnancies and limit family size. The first survey, undertaken in Indianapolis in 1941, involved a sample of 1,977 couples which satisfied the following criteria: both husband and wife native-born white Protestants with at least grade eight education, wed during the period 1927-1929, neither previously married, and both residents of a large city most of the time since marrying. The aim of the study was to examine the relation of family planning and desired family size to given social and psychological factors (Kiser and Whelpton, 1958: 1326-1329). The

Indianapolis Study reported widespread experience with birth control by "relatively fecund" couples before the first and second pregnancies, with increases in the efficacy of use and shifts to the more effective methods of birth control over the marriage period (Westoff et al., 1958: 942-943).

American fertility research since the Indianapolis Study has taken three principal, functionally-related streams. The first stream, exemplified by the longitudinal Princeton Fertility Study, has tested hypotheses about the social and psychological factors that affect current fertility levels.

The sampling criteria for the Princeton Study were restrictive. The initial sample, taken in 1957, comprised 1,165 once-married American-born white couples residing in large metropolitan centres and whose family building had been uncomplicated by marriage dissolution, illegitimacy, multiple births, adoption, child death or pregnancy wastage beyond one miscarriage (Westoff et al., 1961: 16). The second and third rounds of the survey re-interviewed 905 couples in 1960 and 814 in 1963-1967 (Bumpass and Westoff, 1970: 10-12).

The first report of the Princeton Study (Westoff et al., 1961: 70-83) revealed that just over half the couples initiated contraception prior to the first birth while only 11 per cent had never used contraception by the time of the interview. Although social class did not appear to be an important determinant of contraceptive use, religious differentials in both the timing of birth control and methods chosen were marked. In contrast to the Indianapolis Study, there was no tendency for couples to gravitate toward

more effective methods of family planning as marriage duration increased. The second report (Westoff et al., 1963: 38-44) showed that in the absence of religious objections or suspected sub-fecundity couples did resort to more effective means of birth control as their actual fertility approached their desired family size. The third report (Bumpass and Westoff, 1970: 55-73) found that declining fecundity and decreasing coital frequency contributed little to declines in the probability of conception in the later childbearing years. Rather, the high degree of fertilty control experienced by American women has stemmed from increasingly larger proportions of couples employing birth control, shifts to more reliable methods and increased contraceptive vigilance. An important general conclusion of the Princeton Study was that contraceptive use and effectiveness are more sensitive to the stage of family building than to duration of marriage. That is, the motivation to control the spacing of pregnancies is weaker than the motivation to limit the total number of births.

The second stream of American fertility research is represented by the Growth of the American Families Studies of 1955 and 1960 and the National Fertility Study of 1965. The concern here was not so much with testing hypotheses as with supplementing basic census information and describing fertility behaviour in greater depth than existing secondary data sources could allow. National probability samples taken in 1955, 1960 and 1965 involved respectively: 2,713 married women aged 18 to 39 years (Freedman et al., 1959: 10-11); 3,322 married or previously married women between the ages of 18 and 44 (Whelpton et al., 1966: 3-5); and, 5,617 currently married women less than 55 years of age (Ryder and Westoff, 1971: 8-10).

These three surveys have permitted an examination of trends in contraceptive practices over time. While the overall proportion of couples using some form of birth control increased from 70 per cent in 1955 to 84 per cent in 1965 (Ryder and Westoff, 1971: 103), an important pattern of family planning for many couples in the early 1960's was to postpone the use of contraception until one or more pregnancies had occured. The 1955 study (Freedman et al., 1961: 100-132) revealed pronounced differentials in attitudes toward and use of fertility control with respect to levels of education, religion and income. By 1965, however, these differentials had largely disappeared - especially for couples at the higher parity levels, among whom contraception was almost universal. In addition, there has been a general tendency in the recent past for those who do not suffer impairments to their fecundity to shift to the more effective forms of birth control, with the "pill" gaining in overall popularity among all social classes and age cohorts (Ryder and Westoff, 1971: 108-128). Finally, while these studies supported the Princeton hypothesis that the number of children desired influences a couple's ability to control fertility, it was demonstrated that a couple's ability to control fertility also influences desired family size (Whelpton et al., 1966: 293-299; Ryder and Westoff, 1971: 133-136).

Complete results from the 1970 National Fertility Study, which involved a sample of 6,752 ever-married American women under 45 years of age, have not yet been published. However, Rindfuss and Westoff (1974: 75-83) have employed these data to examine trends in the initiation of contraception. Their analysis of women first-married in the 1960's revealed a substantial increase in the proportion

using contraception prior to the first pregnancy. Additionally, members of more recent birth cohorts have tended to shift from a reliance on traditional methods, eg. rhythm, to the pill.

A third stream of American fertility research, exemplified by the work of Rainwater (1960; 1965), concerns the extent to which marital relations affect contraceptive practices. Rainwater's samples, comprising 95 working-class couples in Chicago and Cincinnati and 257 working- and middle-class families in Chicago, Cincinnati and Oklahoma City, preclude the possibility of making broad generalizations. Nevertheless, his work does offer insights into the social and psychological factors influencing the decision to implement and the effectiveness of birth control. Rainwater found an inverse association between the sexual differentiation of marital roles and contraceptive effectiveness. Mutual enjoyment in sexual relationships created a favourable atmosphere for co-operative family planning and minimal interference to its rational use (Rainwater, 1960: 140-141). The tension produced by unequal enjoyment of sexual relationships, on the other hand, affected either the particular methods of contraception a couple found acceptable or the regularity with which it was employed (Rainwater, 1965: 296). This suggests that knowledge of contraception alone, even assuming it to be directly related to family planning motivation, may not be sufficient for the successful realization of contraception.

Canadian Literature

There has never been a comprehensive nation-wide study of reproductive behaviour in Canada. Several surveys conducted in the

recent past have investigated fertility and family planning but restricted themselves to particular cities or regions. In consequence, little is known about the family planning strategies of "representative" Canadian couples.

The first major Canadian survey to investigate contraceptive practices was conducted in Metropolitan Toronto early in 1968 (Balakrishnan et al., 1975). The sample comprised 1,632 once-married women who were under 46 years of age and living with their husbands at the time of the survey. The aims of the Toronto study were two-fold: to probe into reproductive behaviour in greater depth than had hitherto been done for Canada; and, to assess the applicability of American research findings to Canada.

The Toronto study revealed that acceptance of birth control was widespread. Eighty-six per cent of fecund women had used contraception at some time during their childbearing years and more than two-thirds were employing it at the time of the interview. Variation in the extent of use was found, however, between members of different religious and educational groups. The study also reported that the method of birth control employed was related to some degree to a woman's age. Specifically, oral anovulents enjoyed widespread popularity among the young and the recently married, while older cohorts relied to a greater extent on traditional appliance methods (Balakrishnan et al., 1975: 55-78). Separate analyses of the Toronto data (Allingham et al., 1969 and 1970; Balakrishnan et al., 1970) showed, however, that the initial spectacular growth rate in use of oral contraceptives slackened in the late 1960's as younger women

discontinued use to become pregnant and, more importantly, because of widely publicized health hazards attributed to the pill.

Balakrishnan et al. (1975: 58) conjectured that women at all ages, parities and marriage durations were employing contraception not only to limit family size but also to achieve a desired spacing between pregnancies; but, unfortunately, data were not collected which would permit an investigation of contraceptive practices at various stages of the family formation process.

Two surveys - the first in the Eastern Townshipts region of Quebec, the other in Ottawa - have approached family planning from the standpoint of epidemiological research. The pilot study of the Quebec survey (Kelly et al., 1972: 1322-1323) indicated that a majority of the 111 women aged 15 to 59 years who made up the sample were employing no method of birth control. The remainder were divided evenly between "natural" (eg. rhythm) and oral contraceptive methods. The sample was too small, however, to permit an examination of patterns of use and non-use of fertility control among women of childbearing age.

The 1972 Ottawa study (Pool et al., 1973; Pool, 1975), which was primarily concerned with the relationship between female health care and reproductive behaviour, analyzed family planning practices extensively. The sample consisted of 802 women aged between 15 and 45 years who, at the time of the survey, were in a sexual union that involved exposure to the risk of conception for a period greater than three months. Fully 90 per cent of the respondents had used some method of birth control at some time and most had used a multiplicity of methods. Of the 10 per cent who were non-contraceptors, more than

half claimed to be sub-fecund. Socio-economic and cultural differentials in the extent of use as well as in the methods of family planning used proved to be minimal.

Analysis of current users showed that the choice of contraceptive method was related to age, parity and marital duration. The oral contraceptive pill enjoyed its greatest popularity among younger women of low parity who had been married less than ten years. Presumably, nulliparous women were attempting to postpone their first pregnancies and women at parity one to achieve an efficient spacing of births. Use of intra-uterine devices was most prevalent among older, higher parity women, for whom limitation of family size may have been a major concern. This may also reflect, of course, differences in the physiological requirements for or access to the IUD. Sterilization, as a means of family limitation, appeared to be rapidly gaining in acceptance and popularity - particularity among couples at parity three or above and in which the wife was older than 30 years of age.

The Ottawa Study revealed substantial movement between different methods of birth control. While this might be expected for methods that need not be used on a regular basis to be effective, eg. condom, it was also true of those that require regimen or are inconvenient to switch to back and forth, eg. pill, IUD. For example, whereas 65 per cent of the women who had ever used contraception had had experience with the pill, only 22 per cent were still using it when interviewed. The high attrition rates for oral contraceptors might be explained by the concern many expressed for the safety of the pill and by the somewhat surprising finding that contraceptive

failure increased with increasing parity (Pool, 1975: 55-89).

A survey conducted in 1971 in the Province of Quebec (Henripin and Lapierre-Adamcyk, 1974) gathered information about reproductive histories and attitudes toward fertility for a sample of 1,745 ever-married women between the ages of 15 and 65 years. Contraceptive practices were not investigated in depth but evidence did suggest that Quebec couples were averting about 60 per cent of the births that would otherwise occur. With the exception of slight tendencies for women less than 35 years of age to favour oral contraception and for women aged 35 to 50 to favour rhythm, age differentials in the methods of birth control used were minimal. The extent of use of family planning, however, was found to be significantly greater among younger age cohorts (ibid., 106-108).

Three other papers might also be noted briefly. A study by Okraku (1972), which examined data on exposure to intercourse among non-contracepting couples in a Nova Scotian fishing village, found that short but frequent separations of spouses led to low fertility by reducing coital frequency. Grindstaff and Ebanks (1971), in a London, Ontario study involving men who had had vascectomies between 1966 and 1969, found that the length of time contraceptive methods were used decreased with the order in which they were used and that couples were shifting to more reliable techniques and employing them more effectively as family size increased. Although they do not justify their claim that 75 per cent of all sterilization operations are performed on men, there is little doubt that vascectomy is becoming increasingly acceptable as a means of fertility control in Canada. Findings from a recent survey in Toronto (Simmons and

Turner, 1974) suggest that inter-generational transmission of norms may constitute an important determinant of desired family size (and, presumably, attitudes toward family planning).

This overview of previous North American studies indicates that contraception, though widespread, is being employed by couples at different parity levels with varying degrees of success. The most effective fertility control is being achieved by young couples which are trying to postpone family formation and by couples of high parity which are seeking to limit completed family size. A general trend in the last decade among those who are not sub-fecund has been to shift to the more reliable methods of birth control as desired family size is reached. Nevertheless, changes between methods over the short-term are common. While socio-economic and cultural differentials in contraceptive use have largely disappeared in the United States, regional and ethnic variations in either the extent of use or the methods chosen may persist in Canada.

The Problem

The object of the present study is to investigate the strategies that Edmonton couples adopt to regulate their fertility at different stages of the family cycle. The thesis will focus on the contraceptive methods - and, in particular, on shifts between methods - employed by couples at different parity levels.

In Chapter II, the sample will be introduced and characteristics of current users of birth control described. In ensuing chapters, a stochastic model of family planning will be developed and subsequently employed to analyze patterns of contraceptive use in Edmonton.

CHAPTER II

CHARACTERISTICS OF CURRENT FAMILY PLANNERS

The Sample

The data analyzed in this thesis are drawn from the Growth of the Alberta Families Study (GAFS). The entire sample comprises 1,045 women who were between the ages of 15 and 54 years and residing in the city of Edmonton at the time of the survey. Interviews were conducted between 19 November 1973 and 15 February 1974, with a median date of 15 December 1973.

The GAFS survey employed a two-stage sampling design. First, from a list of Edmonton census enumeration areas stratified in terms of their ethnic compositions at the time of the 1961 census, sixty areas were chosen so as to ensure that those with a preponderance of French, German, Ukranian or Polish groups had higher probabilities of selection. Address lists were then compiled for the selected enumeration areas and sampling ratios determined so that systematic sampling would yield approximately thirty-eight contacts per area. A summary of the outcomes of contacts with the resulting 2,300 households is as follows:

	Number	Per Cent
Completed interview	1,045	45.4
No eligible respondent	662	28.8
Refusal	221	9.6
Vacant household	132	5.7
No contact after four call-backs	107	4.7
Eligible respondent unavailable	101	4.4
Other	32	1.4
TOTAL	2,300	100.0

Assuming that "refusals" and "others" were eligible to be interviewed,

the response rate was approximately 75 per cent of the eligible women contacted.

Weighting factors for the completed interviews were obtained by multiplying the number of eligible respondents in each selected household by the sampling ratio of the enumeration area (Beaujot, 1975: 38-39). Excepting sample and sub-sample sizes, all data analyzed here are weighted.

The acronym "GAFS" is somewhat misleading as the sample does not purport to be representative of the Province of Alberta. It seems reasonable to accept that the sample is fairly representative of the city of Edmonton. As Beaujot (1975: 42) notes, however, drawing the sample on the basis of the 1961 census (the 1971 data on ethnicity being unavailable when the sample was fixed) resulted in under-estimations of the British and Ukranian groups and an over-estimation of other Europeans.

In studying family planning practices, one is restricted to the sub-sample of women who were living in either de jure or de facto marriages and, hence, presumably somewhat continuously/continually exposed to the risk of conception. A total of 736 women, or 70.3 per cent of those interviewed, satisfied this criterion. The proportionate age distributions of married women in the sample and in Edmonton at the time of the 1971 census are as follows:

Age Group	Sample (%)	1971 Census (%)
15-19	4.9	2.6
20-24	18.9	16.9
25-29	16.3	17.4
30-34	15.0	14.8
35-39	10.3	13.9
40-44	14.8	13.1
45-49	9.8	12.1
50-54	10.0	9.2
TOTAL	100.0	100.0
(n)	(736)	(95,525)

Comparing the weighted sub-sample distribution with the distribution of the 1971 census indicates general agreement with respect to age. The mean and median ages of married women in the sample were 34.1 and 32.9 years respectively. The average length of time married was 12.1 years with a median value of 10.1 years.

The mean number of children per married woman in the sample was 2.04 with a median of 1.92. The distribution of respondents by parity was as follows:

Parity	Per Cent
0	23.9
1	15.8
2	24.5
3	18.4
4	9.4
5+	8.0
TOTAL	100.0
(n)	(736)

Unfortunately, a comparison of this distribution with the distribution in 1971 for Edmonton as a whole is not possible as the census does not contain information on currently married women by parity.

Forty-seven of the married respondents failed to report whether they or their partners had ever used any form of birth control. These women have been excluded from the analysis, thus reducing the

the size of the sub-sample to 689 (or 64.9 per cent of the total number of women interviewed).

General Contraceptive Use

Respondents were asked to indicate the methods of birth control, if any, which they and their spouses had used in the past or were using at the time of the survey. In all, 90.6 per cent of the couples in the sub-sample had used some method of family planning and many had used several methods. Twenty-nine per cent of the women reporting no experience with contraception mentioned medical or physical problems which made conception either difficult or impossible. The lowest incidence of contraceptive use occurred among the nulliparous and the highest among couples at parity two and above. Predictably, the number of current users was less than the number who had ever used birth control. Nevertheless, current use was high: 82.0 per cent of the women interviewed were employing some means of fertility control during the period immediately prior to the survey.

The proportionate distributions of all couples by family planning methods ever-used and currently used are shown in Table I. In the case of current users, respondents who were employing more than one method have been coded under the one they reported using most. Oral anovulents prove to be the most popular birth control method overall; approximately 55 per cent of the sample, or 60.6 per cent of those with contraceptive experience, had employed the pill at some time. A large proportion of the couples - nearly 32 per cent of the total - had adopted contraceptive sterilization as a means of permanently curtailing fertility. Important differences exist between the

TABLE I

Percentage Distributions of Couples by Family Planning Methods Ever-Used and Currently Used

Method	Ever-Users (%)	Current Users (%)
Traditional[1]	13.7	2.6
Rhythm	16.1	2.7
Condom	19.9	5.4
Diaphragm-Foam	23.8	4.6
IUD	8.9	3.9
Pill	54.8	31.6
Male Sterilization	7.7	7.7
Female Sterilization[2]	23.8	23.8
Other[3]	2.0	0.3
None	9.4	17.4
Total	n/a[4]	100.0
(n)	(689)	(689)

(1) Includes abstinence, coitus interruptus, douche and breast feeding

(2) Including hysterectomies

(3) Includes abortion, injection and suppositories

(4) Since many couples had used several methods, this total exceeds 100 per cent.

number who had ever used and who were currently using the various temporary measures. This is particularily true for methods not requiring medical supervision. For example, whereas half the couples had used rhythm, condom or traditional methods, less than 11 per cent were employing these methods when interviewed.

Attrition rates relating current users of different temporary contraceptive measures to ever-users are presented in Table II. High attrition rates for all methods, coupled with extensive current use of fertility control overall, suggest that many respondents may have been cycling between methods rather than terminating contraception altogether. The relatively low rate of discontinuation associated with the IUD suggests that use of the IUD may be "parity-progressive" in that the success of installation and/or requirements for doctors to agree to install the device may increase with parity. Relatively low rates for both the IUD and the pill indicate an increasing tendency to rely on the more effective temporary methods of birth control. Part of the explanation for differential attrition rates may lie, however, in the age of a couple and the stage of family formation it has reached. For example, older and higher parity couples may have been abandoning traditional and appliance methods in favour of contraceptive sterilization as desired family size was achieved, while couples of lower parity were relying to a greater extent on temporary birth control methods that will allow an efficient timing and spacing of births. Durations of use and changing distributions of methods used to prevent conception at different stages of the family cycle will be examined in detail in Chapter IV.

TABLE II

Method-Specific Attrition Rates(1)

Method	Attrition Rate
Traditional	0.811
Rhythm	0.829
Condom	0.730
Diaphragm-Foam	0.805
IUD	0.557
Pill	0.425
Other	0.857

(1) attrition rate = $1 - \frac{\text{no. of current users}}{\text{no. of ever-users}}$

Background Factors to Contraceptive Use

As noted in the preceeding chapter, there has been a convergence in the extent of use and the family planning methods used by members of different socio-economic and cultural groups in the United States. In contrast, Canadian studies suggest that social and regional variations in the extent of use of birth control may persist. For example, whereas the 1972 Ottawa study (Pool, 1975) found social differentials in current contraceptive use to be minimal, studies in Toronto (Balakrishnan et al., 1975) and Quebec (Henripin and Lapierre-Adamcyk, 1974) indicated that factors, such as religion and education, may influence the implementation of birth control.

In the present section, use of birth control has been examined in light of various socio-economic and demographic characteristics of the sample. The respondents were first stratified with respect to their fecundity and current family planning practices. The variable thus defined was then cross-tabulated with a number of background variables to test whether these are related to current contraceptive use.

The variables employed and the categories into which they were codes are as follows:

Current Status
1 User of temporary contraceptive method
2 User of permanent contraceptive method
3 Non-contraceptor
4 Sub-fecund

Age
1 Early childbearing period: 15-29 years
2 Middle childbearing period: 30-44 years
3 Late childbearing period and menopausal: 45-54 years

Marital Duration
1 0-4 years
2 5-9 years
3 10-14 years
4 15-19 years
5 20 years or more

Parity
1 Nulliparous
2 One
3 Two
4 Three
5 Four or more

Ethnicity on Father's Side
1 British
2 French
3 Other Western European
4 Ukranian
5 Other Eastern European
6 Other

Religion
1 Protestant
2 Catholic
3 Other
4 None

Origin
1 Rural
2 Urban

Education
1 High school not completed
2 High school completed
3 Post-secondary training

Occupation
1 Housewife
2 Student
3 Employed in the labour force

Family Income in 1973
1 Under $10,000
2 $10,000 - $14,999
3 $15,000 and over

Individual contingency tables are not shown; however, a listing of the cross-tabulations, with associated summary statistics, is contained in Table III. The value of the chi-square test statistic will invariably

TABLE III

Cross-tabulations with Associated Summary Statistics

Cross-tabulation	Chi-square	d.f.	Cramer's V
1. Current Status x Parity	149.92*	12	0.270
2. Current Status x Age	241.88*	6	0.421
3. Current Status x Marital Duration	194.31*	12	0.310
4. Current Status x Ethnicity	16.20†	15	0.089
5. Current Status x Religion	10.23†	9	0.071
6. Current Status x Family Income	6.76†	6	0.074
7. Current Status x Origin	3.98†	3	0.082
8. Current Status x Occupation	10.44†	6	0.107
9. Current Status x Education	44.26*	6	0.180
9a. Current Use(1) x Education x Age			
i 15-29 years	1.86†	2	0.083
ii 30-44 years	3.45†	2	0.112
iii 45-54 years	3.09†	2	0.149
10. Education x Age	42.03*	4	0.169
11. Parity x Age	274.30*	8	0.432
12. Parity x Marital Duration	429.76*	16	0.385
13. Marital Duration x Age	703.08*	8	0.696

* Significant at the 0.001 level

† Not significant at the 0.05 level

(1) Created by collapsing categories of "Current Status"; see text.

be inflated by a sampling ratio if the weighting is not inversely correlated with the degree of association among the sub-strata. It should be noted, therefore, that the actual probabilities associated with the chi-squares reported in the table may in general be higher than indicated.

The three demographic variables considered are significantly related to current contraceptive status - the overall extent of contraceptive use increases with parity, age and marital duration. Use of temporary measures shows an inverse and contraceptive sterilization shows a direct relationship with each of these variables. For example, whereas the proportion of couples employing temporary methods of birth control drops from 70.7 per cent among the nulliparous to 27.9 per cent among those at parity four and above, the proportion of couples in which one of the partners had been sterilized increases from 6.8 to 51.0 per cent between the same parity levels (tables not shown).

Parity, age and duration of marriage are, of course, closely linked; see cross-tabulations 11, 12 and 13, Table III. For example, the likelihood of having undergone sterilization is highest among those who have been married for some time since many such couples have presumably already achieved their desired family sizes. At the same time, the relative frequency of recognized sub-fecundity and secondary sterility is greatest among older and longer-married women. Unfortunately, small cell frequencies and large frequencies of "missing values" make the use of discrete multivariate analytic techniques (for discussions, see Bishop et al., 1975) to disaggregate the

separate effects of each of the three demographic variables on current contraceptive status impossible.

In general, the various socio-economic and cultural factors examined are not significantly related to current contraceptive status. The sole exception occurs in the case of the respondents' educational attainments, where the relationship is apparently significant at the 0.001 level. This association may stem, however, from the relationship of both education and current contraceptive status with a third variable. Since popular access to higher education is relatively recent, younger women can be expected to have completed more years of formal education on the average than had their older sisters - a speculation borne out by findings presented in Table III (cross-tabulation 10). The type of birth control measure employed, as well as the incidence of secondary sterility, also depends in part, however, on a respondent's age. The association between education and current status is contingent on these two further marginal relationships.

To demonstrate confounding, the relationship between education and current contraceptive status must be stratified on age. The resulting contingent associations should then disappear. Small sub-sample sizes led to the situation where many of the expected cell frequencies were less than five. Since this may inflate the values of the chi-square test statistics (beyond the levels emanating from weighted data), the variable "Current Status" was collapsed into two categories: "contraceptors", subsuming users of both temporary and permanent methods of birth control, and "non-contraceptors", including the sub-fecund. As indicated in Table III (cross-tabulation 9a),

cross-tabulating the recoded variable with education within different age groups no longer shows a significant marginal relationship between contraceptive use and education.

The cross-tabulations shown in Table III were replicated with the data unweighted. The significance levels of the unweighted chi-squares were generally lower than those of the corresponding weighted statistics. An exception occurs in the case of current contraceptive status by occupation ($\chi^2 = 12.83$, $\alpha < 0.05$) but this could be due to chance. For these data, therefore, the weighted chi-square test appears to give a slightly better fit to independence when the relationships are not significant.

Method-Specific Contraceptive Use by Parity

Table IV contains the percentage distributions of couples by contraceptive method currently employed and parity. It is evident from the table that family size has an important bearing on the method of birth control currently used. This is especially true for oral anovulents and sterilization, which together account for 75 per cent of current contraceptors. The widespread use of the pill by women at parities zero and one declines sharply with increasing parity in favour of female sterilization and, to a lesser extent, vascectomy. Apart from the apparent desire of higher parity couples to terminate childbearing, age-parity differentials in the extent of contraceptive sterilization may reflect differences in access to permanent methods of fertility control.

Patterns of use are not readily discernible among the other methods shown as the numbers employing any particular method are

TABLE IV

Percentage Distributions of Couples by Family Planning Methods Currently Used and Parity

Method	Parity				
	0	1	2	3	4 or more
Traditional[1]	1.6	2.1	2.6	4.0	3.0
Rhythm	2.9	1.8	4.2	3.7	0.8
Condom	1.8	3.8	10.4	7.0	2.8
Diaphragm-Foam	2.7	5.4	5.6	4.7	5.3
IUD	1.8	7.2	4.9	4.4	2.2
Pill	60.0	45.9	27.3	10.5	12.7
Male Sterilization	0.0	2.6	9.5	14.7	11.9
Female Sterilization[2]	6.8	9.2	27.1	35.5	39.1
Other[3]	0.0	0.0	0.0	0.0	1.2
Total	100.0	100.0	100.0	100.0	100.0
(n)	(155)	(105)	(171)	(126)	(126)

(1) Includes abstinence, coitus interruptus, douche and breast feeding

(2) Including hysterectomies

(3) Includes abortion, injection and suppositories

small and percentage differences minimal. Use of the IUD and appliance methods, viz. diaphragm and condom, does appear, however, to be slightly more prevalent among couples at parity one and above. This may indicate a reluctance on the part of these couples to abandon methods they have found satisfactory in the past or, perhaps, ambivalence toward spacing or delaying pregnancies.

Non-contraception by women of low parity suggests that many, if not already pregnant, may have been postponing use of birth control until after one or two children had been born. Non-use at the higher parity levels may reflect low coital frequency for older couples and the declining fecundity of older women.

Other concomitant factors, about which one can only speculate, may also be operating. The decision to employ a temporary as opposed to a permanent method of birth control may be contingent on the stability of the union; ie., individuals contemplating divorce and remarriage may have been hesitant to adopt any measure that would curtail the ability to start another family in the future. The choice of methods may also depend in part on the extent to which couples take advantage of the family planning counsel and facilities available to them. While only 1.9 per cent of the respondents claimed to have no knowledge of contraception, many couples - particularily those using no contraception or inefficient methods - may possess sketchy or unreliable birth control information. Additionally, in a male-dominated society such as Canada, the onus of responsibility for sterilization may be seen to rest largely with the female.

CHAPTER III

A STOCHASTIC REPRESENTATION OF FAMILY PLANNING

Stochastic Models

The application of the theory of stochastic processes has become increasingly prevalent in sociological research. In contrast to classical statistical techniques, such as regression analysis, which typically attempt to explain variations in one or more variables by reference to auxiliary or concomitant factors, the stochastic approach views human behaviour as processes that develop in time according to probabilistic laws. An essential distinction between these alternative approaches to model construction lies in the nature of the predictions they allow. A deterministic model yields as a rule a specific prediction, based on average group performance, of the effects of any change in the system. A stochastic model normally predicts a whole distribution of outcomes, each with an associated probability of occurrence.

Most sociological applications of stochastic theory have aimed at developing models of social or geographical mobility. Bartholomew (1973: 381-412) has provided a comprehensive bibliography of social applications of stochastic models. (For recent Canadian examples, see Beaman and McGinnis, 1974; Stone, 1974; Tripathi and Krishnan, 1974; Krishnan and Sangadasa, 1975.) Ebanks (1970) has employed the notion of a Markov chain to test for stationarity over time in patterns of contraceptive use among members of a family planning programme on the island of Barbados.

The theory of finite Markov chains (for discussions, see Feller, 1957; Kemeny and Snell, 1963; Bartos, 1967; Chiang, 1968; Bartholomew, 1973) will be used in the present study to analyze patterns of family planning among Edmonton couples. In this chapter, basic ideas underlying Markov chains will be introduced and an absorbing Markov chain model developed with reference to family planning. Results obtained from the application of this model to data on contraceptive practices in Edmonton will be presented in Chapter IV.

Finite Markov Chain

Consider the set that includes all possible methods of birth control and non-contraceptive use. The elements of this set will be denoted as states; and, together they will define the state space of the system. To simplify the exposition, let us assume that the state space comprises only four (discrete) categories: three methods of contraception and non-contraceptive use.

Suppose that a couple observed at time t during the wife's reproductive span is using family planning method i ($i = 1, \ldots, 4$). At time t+1, the couple may decide to continue using that method, switch to a different method, or cease contraception. If the decisions to continue using that technique or to change states are governed by a stochastic mechanism, conditional probabilities, $p_{ij}^{(t)}$'s, which describe the likelihoods that the couple will be using method j at time t+1 given that it was using method i at time t, can be assigned. And, a transition matrix, $P^{(t)} = (p_{ij}^{(t)})$, that describes all possible movements between the various family planning methods

during the interval t to t+1, can be constructed. Since the system is closed, $\sum_j p_{ij}^{(t)} = 1$ $(i,j = 1, \ldots, 4)$.

(It would be useful to clarify notation at this point. Uppercase Roman letters represent matrices; lowercase Greek letters are vectors.)

Let $\pi^{(t)'}$ denote a probability row vector with four components, each corresponding to the proportion of couples in the various states of the model at time t. If all couples employing a particular family planning method at time t are subject to an identical transition probability, then $\pi^{(t+1)'}$, the distribution of couples at time t+1, is given by

$$\pi^{(t+1)'} = \pi^{(t)'} P^{(t)} \quad . \tag{1}$$

If we further assume that the values of the transition probabilities are independent of time, so that a couple moving into a category at time t assumes the probabilities pertinent to that category, equation (1) can be reformulated as

$$\pi^{(t+1)'} = \pi^{(t)'} P \quad , \tag{2}$$

where P is a time-homogeneous transition matrix. That is, the outcome depends only on the immediately preceding outcome and the (stationary) transition probabilities. In general, the outcome at time t+n is

$$\pi^{(t+n)'} = \pi^{(0)'} P^{t+n} \quad , \tag{3}$$

where $\pi^{(0)'}$ is the initial distribution of couples among the states of the model. Thus, once the initial distribution vector is given and the values of the transition probabilities known, the state of the system at each subsequent time period is determined.

A basic characteristic of any stochastic process is its reliance on the state space and the parameter space. The state space of the model presented here is the set of contraceptive categories and the parameter space comprises the transition probabilities and time. The model is a finite Markov process in the sense that the current state of the system depends only on the immediately prior outcome. It is a stationary finite Markov chain since the transition matrix is homogeneous in time and both the state space and time have been implicitly assumed to be discrete.

Absorbing Markov Chain

Methods of family planning can be classified as either temporary or permanent. Use of a temporary method at one time does not preclude the possibility of a couple's switching to another method in the future. In contrast, sterilization, whether male or female, is virtually irreversible. Once either partner to a marriage has undergone the operation, the couple's future family planning behaviour is assumed to be fixed.

Temporary and permanent contraceptive measures can be treated as elements of transient and ergodic sets. The former, once left, can never be re-entered; the latter, once entered, can never be left. A state that is itself an ergodic set is said to be absorbing. And, a Markov chain that has at least one such state and in which it is possible to reach an absorbing state from every transient state (though not necessarily in a single step) is termed an absorbing Markov chain.

For an absorbing state, s_i, transition probability p_{ii} is

unity and the remaining entries in the i^{th} row of the transition matrix are zeros. By suitably arranging its rows and columns, the transition matrix P can be partitioned into transient and ergodic sets. This yields the canonical form of the matrix,

$$P = \begin{array}{c} \\ s_1 \\ s_2 \\ s_3 \\ s_4 \end{array} \begin{array}{c} \begin{array}{cc} s_1 & s_2 \end{array} \quad \begin{array}{cc} s_3 & s_4 \end{array} \\ \left[\begin{array}{cc:cc} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ \hdashline p_{31} & p_{32} & p_{33} & p_{34} \\ p_{41} & p_{42} & p_{43} & p_{44} \end{array}\right] \end{array}$$

where s_1 corresponds to female and s_2 to male sterilization.

It is convenient to adopt the following notation for the aggregated version of the canonical matrix:

$$P = \left[\begin{array}{c:c} I & \emptyset \\ \hdashline R & Q \end{array}\right]$$

The sub-matrix $\emptyset$ consists entirely of zeros. Sub-matrix Q concerns the process so long as it stays in the transient set; R concerns movements from the transient to the ergodic sets; and, the identity matrix I characterizes the process after it has entered an absorbing state.

In any finite Markov chain, regardless of where the process starts, the probability of being in an ergodic set tends to one as the number of steps approaches infinity. In terms of our characterization of family planning, this means that given sufficient time all couples would ultimately adopt contraceptive sterilization to limit their fertility. What is of concern here, however, is not that all couples would ultimately reach an absorbing state, but their family

planning behaviour while in the states of the transient set.

Applications of the Model

A number of quantities that describe the behaviour of an absorbing Markov process while in the states of the transient set have been developed. Since the derivations of these quantities have been presented in detail elsewhere (see, for example, Kemeny and Snell, 1963: 46-66), only the results will be stated.

The short-term behaviour of couples currently in a transient state can be studied with the aid of the sub-matrix Q. The vector, δ, which gives the expected number of times a couple will continue to employ a temporary method of birth control once it has started using it, is given by

$$\delta = (I - Q_{dg})^{-1}\xi \quad , \tag{4}$$

where I is an identity matrix, Q_{dg} is the matrix that results from setting off-diagonal elements of Q to zero and ξ denotes a vector with all entries equal to one. The variance of this quantity, δ_2, defined as the second moment about the mean, can be shown to be

$$\delta_2 = Q_{dg}\delta_{sq} \quad , \tag{5}$$

where δ_{sq} is the vector obtained by squaring each element of δ.

For a couple in transient state i, the conditional probability of moving to any other state j given that state i is left, is

$$C = (I - Q_{dg})^{-1}(Q : R) \quad , \tag{6}$$

where the matrix $(Q : R)$ is obtained by adjoining R to Q, and noting that probabilities c_{ii} are undefined.

To study secular patterns of contraceptive use, we need to

define the fundamental matrix, N, of the absorbing Markov chain such that

$$N = (I - Q)^{-1} , \tag{7}$$

where I is an identity matrix. The fundamental matrix has an immediate probabilistic interpretation. The general element, n_{ij}, gives the mean number of times that a couple starting in temporary contraceptive category i will be temporary category j if the process goes to absorption. The variance of the fundamental matrix is defined as

$$N_2 = N(2N_{dg} - I) - N_{sq} . \tag{8}$$

Here, N_{dg} is the matrix that results from setting off-diagonal elements of the fundamenal matrix equal to zero and N_{sq} is obtained by squaring each entry of N.

For a couple starting in any transient state, the total number of steps, τ, taken before adopting contraceptive sterilization is given by

$$\tau = N\xi \tag{9}$$

with associated variance

$$\tau_2 = (2N - I)\tau - \tau_{sq} , \tag{10}$$

where the vector τ_{sq} is obtained by squaring each element of τ.

Although the variance is an adequate way of describing the degree of variability in a distribution, it does have the drawback of being expressed in squared units of measurement. To be more readily interpretable, the quantities given in equations (5), (8) and (10) can be transformed into standard deviations by taking the positive square root of each entry of the vector or matrix.

We can next examine the probabilities that a couple which

reported using a specific temporary method of birth control at the beginning of the process will ever adopt other temporary methods at later times. These probabilities are given by

$$H = (N - I)N_{dg}^{-1} \quad . \tag{11}$$

The total number of temporary methods a couple can be expected to use before ultimately adopting contraceptive sterilization is

$$\mu = N(N_{dg}^{-1})\xi \quad . \tag{12}$$

Finally, we can assess the likelihoods that couples will opt for female or male sterilization to limit their completed family sizes. Specifically, the probabilities of a couple's starting in a particular temporary contraceptive category and ultimately choosing either male or female sterilization are given by

$$B = NR \quad . \tag{13}$$

Modifying the State Space

In the interests of simplicity, all couples have been considered up to now without respect to the number of children they have borne. If the absorbing Markov chain model is to provide an adequate representation of patterns of family planning, it should take into account not only contraceptive methods but family size as well. Such an elaboration of the model can be accomplished simply by expanding the state space so that the various forms of birth control are considered jointly with parity levels. A further state can also be added to take the onset of secondary sterility and menopause into account. In the next chapter, an absorbing Markov model that incorporates these modifications will be applied to analyze data pertaining

to family planning practices in Edmonton.

CHAPTER IV

PATTERNS OF FAMILY PLANNING

The Transition Matrix

The Growth of the Alberta Families Study asked each married or co-habiting respondent to specify the dates of entry into and, where applicable, exit from marital unions, past and current use of birth control, the dates of antecedent birth confinements and whether she believed herself to be currently fecund. By combining these items, the fertility history of each couple can be reconstructed.

Data collected about the timing of contraception are not comparable throughout the study. Questions about family planning practices during the six-year period prior to the survey pertain to two-year intervals. For contraceptive use prior to 1968, the period at risk ranges from three to twelve years. Since the model developed in the last chapter requires that time intervals be of equal span, we are restricted to the intervals beginning in 1968, 1970 and 1972. This limitation reduces the amount of useful information that can be analyzed. However, it may also minimize possible inaccuracies in the data stemming from faulty recall as well as the effects of changes in patterns of contraceptive use since the mid 1960's created by the introduction of the pill and the increasing availability of contraceptive sterilization.

To maintain a manageable model, not all methods of birth control and parity levels will be considered separately. The state space, comprising twelve transient and seven absorbing states, will

be defined by the following:

State	Parity: Method
1	0: Non-contraception
2	0: Other temporary methods
3	0: Oral anovulents
4	0: Male and female sterilization
5	1: Non-contraception
6	1: Other temporary methods
7	1: Oral anovulents
8	1: Male and female sterilization
9	2: Non-contraception
10	2: Other temporary methods
11	2: Oral anovulents
12	2: Male sterilization
13	2: Female sterilization
14	3+: Non-contraception
15	3+: Other temporary methods
16	3+: Oral anovulents
17	3+: Male sterilization
18	3+: Female sterilization
19	All: Secondary sterility and menopause

States corresponding to sterilization and to secondary sterility and menopause are assumed to be absorbing; the remainder are transient. States 2, 6, 10 and 15 subsume abstinence, coitus interruptus, douche, breast feeding, rhythm, condom, IUD, diaphragm-foam, injection and suppositories. Although the techniques included in the "Other temporary methods" categories are numerous, the actual proportions of couples employing these methods at different parity levels were small (see, for example, Table IV, Chapter II). The codes given above will be used to label all tabular results presented in this chapter.

The canonical form of the estimated stochastic matrix that

describes movements between the various states over a two-year period is shown in Table V. It is actually possible to obtain two estimates of the transition matrix by cross-tabulating the marginal distributions of couples in the states of the model between 1968-1970 and 1970-1972. Since the retrospective nature of the survey reduces the number of couples considered as one goes back in time and the number of time points is too few to allow a statistical test to check for stationarity, the estimated matrix shown is based on the average numbers of reported moves during each of these two-year periods.

Not all movements among the transient states and from the transient to the ergodic set are possible. This corresponds to the fact that no couple increased more than two parity levels in a single step and that once having reached a parity level, couples cannot later revert to a lower one. There is a good deal of movement between family planning methods, both within and between parity levels. In general, however, the highest probabilities in the transient set lie on the diagonal. This indicates that in the short-term many couples remain at their current parity levels while continuing to use their current methods of birth control. In other words, a two-year period may have only minimal implications for fertility and family planning.

Since the transition matrix pertains to two-year intervals, some movements have been lost. For example, a nulliparous woman who was using oral anovulents could not advance to parity two in one step without having moved to non-contraception at parities zero and one in the intervening period (assuming, of course, that no multiple births occurred). It must be stressed, therefore, that the transition

TABLE V

Transition Matrix in Canonical Form

	4	8	12	13	17	18	19	1	2	3	5	6	7	9	10	11	14	15	16
4	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1	.02	.04	0.0	0.0	0.0	0.0	.01	.48	.07	.21	.02	.05	.04	.02	.01	.04	0.0	0.0	0.0
2	0.0	.02	0.0	0.0	0.0	0.0	0.0	.12	.35	.21	.02	.21	.05	0.0	0.0	.02	0.0	0.0	0.0
3	.01	.02	0.0	.02	0.0	0.0	.03	.05	.02	.41	0.0	.04	.17	.01	.03	.17	0.0	0.0	0.0
5	0.0	.06	.02	.03	0.0	0.0	0.0	0.0	0.0	0.0	.48	.13	.17	.03	.05	.03	0.0	0.0	0.0
6	0.0	.08	.04	.10	0.0	.04	0.0	0.0	0.0	0.0	.06	.18	.08	0.0	.22	.14	0.0	.04	0.0
7	0.0	.06	.07	.03	0.0	0.0	.01	0.0	0.0	0.0	.06	.09	.49	.01	.01	.16	0.0	0.0	0.0
9	0.0	0.0	0.0	.12	.03	.03	.02	0.0	0.0	0.0	0.0	0.0	0.0	.52	.08	.08	.08	.03	0.0
10	0.0	0.0	.04	.11	.05	.04	.04	0.0	0.0	0.0	0.0	0.0	0.0	.02	.63	0.0	.02	.06	0.0
11	0.0	0.0	.07	.10	.01	.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.04	.09	.62	0.0	.01	.04
14	0.0	0.0	0.0	0.0	.05	.15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.73	.03	.04
15	0.0	0.0	0.0	0.0	.06	.16	.07	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.68	.02
16	0.0	0.0	0.0	0.0	.06	.12	.01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.05	.06	.70

matrix does not provide a complete description of movements between the different states. It should also be noted that expected times and standard deviations calculated from equations (4), (5), (7), (8), (9) and (10) in Chapter III have been doubled in the present chapter to represent years.

Current Family Planners

Table VI contains estimates of the number of years, with associated standard deviations, couples currently employing a temporary method of birth control will continue to use that method before switching to another. Expected times for non-contraception are similar at parities zero, one and two. In contrast, durations of use for oral contraceptives increase with parity while those for other temporary methods first decline between parities zero and one and then increase. The parity-specific durations of use for the pill suggest that it was being employed to achieve progressively longer intervals between successive births. The pattern seen in durations of use for other temporary birth control methods indicate that low parity couples were bearing children rapidly or shifting to more effective means of fertility control. However, higher parity couples appear to have been using other temporary methods with some measure of success. The relatively long durations spent in states 14, 15 and 16 result in part, of course, from combining parities three and above.

Standard deviations in all cases are of the same order of magnitude as the estimated times spent in a transient state, indicating that the estimates are fairly unreliable. This has been found to be a common occurrence in sociological applications of Markov chains (see,

TABLE VI

Expected Durations of Use and Standard Deviations for Temporary Methods of Birth Control

Parity	Use-Parity State*	Expected Duration (years)	Standard Deviation (years)
0	1	3.8	2.6
	2	3.1	1.8
	3	3.4	2.2
1	5	3.9	2.7
	6	2.5	1.1
	7	3.9	2.7
2	9	4.2	3.0
	10	5.4	4.3
	11	5.3	4.2
3+	14	7.4	6.4
	15	6.3	5.2
	16	6.7	5.6

* See text for explanation of codes for states

for example, Kemeny and Snell, 1963: 191-199) and suggests that, due to the inherent variability of human behaviour, Markov chains may be largely inapplicable to social analysis.

A better indication of short-term family planning practices is provided by the conditional probabilities of a couple's moving to another state of the model given that the current state is left. These probabilities, which are shown in Table VII, suggest that short-term shifts between methods are related to both parity and family planning methods currently employed.

If they move, non-contraceptors at parities zero and one will adopt the oral anovulent pill in order to remain at their current parity levels. For those experiencing increases in parity, however, the probabilities are quite similar that they will adopt no contraception, the pill, other temporary contraceptive methods or sterilization. Nulli- and uni-parous couples currently employing other temporary birth control methods will switch to the pill if they are to remain at their current family sizes; but, they are equally likely to bear a child and then continue using that class of methods. Current oral contraceptors at these parities are most likely to have one or more children - presumably by design - and then revert to the pill.

At parities two and above, regardless of the method currently used, the probability of a couple's resorting to sterilization to curtail fertility is high. There is a tendency, however, for both non- and oral contraceptors to remain at their current parity levels and adopt another temporary method of birth control. In contrast, women already employing other temporary methods, if they move, are more likely to reach menopause than to adopt either the pill or no

TABLE VII

Conditional Probabilities of Shifting to Other States (j)
Given that Current State is Left (i)

i \ j	1	2	3	5	6	7	9	10	11	14	15	16	4	8	12	13	17	18	19
1	*	.14	.41	.04	.09	.07	.04	.02	.07	0.0	0.0	0.0	.04	.07	0.0	0.0	0.0	0.0	.02
2	.18	*	.32	.04	.32	.07	0.0	0.0	.04	0.0	0.0	0.0	0.0	.04	0.0	0.0	0.0	0.0	0.0
3	.09	.04	*	0.0	.07	.29	.01	.06	.29	0.0	0.0	0.0	.01	.04	0.0	.04	0.0	0.0	.06
5	0.0	0.0	0.0	*	.24	.33	.06	.09	.06	0.0	0.0	0.0	0.0	.12	.03	.06	0.0	0.0	0.0
6	0.0	0.0	0.0	.07	*	.10	0.0	.27	.18	0.0	.05	0.0	0.0	.10	.05	.12	0.0	.05	0.0
7	0.0	0.0	0.0	.11	.18	*	.02	.02	.32	0.0	0.0	0.0	0.0	.11	.14	.07	0.0	0.0	.02
9	0.0	0.0	0.0	0.0	0.0	0.0	*	.17	.17	.17	.07	0.0	0.0	0.0	0.0	.24	.07	.07	.03
10	0.0	0.0	0.0	0.0	0.0	0.0	.06	*	0.0	.06	.16	0.0	0.0	0.0	.10	.29	.13	.10	.10
11	0.0	0.0	0.0	0.0	0.0	0.0	.10	.24	*	0.0	.03	.10	0.0	0.0	.17	.28	.03	.03	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	*	.10	.14	0.0	0.0	0.0	0.0	.19	.57	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	*	.07	0.0	0.0	0.0	0.0	.20	.50	.24
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	.16	.20	*	0.0	0.0	0.0	0.0	.20	.40	.04

* Probability undefined

contraception. This indicates that these women are older and, in addition, may be somewhat reluctant to give up methods they have found satisfactory in the past.

In sum, the quantities shown in Tables VI and VII suggest a number of short-term patterns of family planning. At the lower parities, current non-contraceptors were shifting to oral anovulents to delay the first or second pregnancy; couples already using the pill were both motivated to achieve and achieving desired spacings between births; and, users of other temporary contraceptive methods were either switching to the pill to delay births or forming families rapidly. For higher parity couples, there was a progressive adoption of sterilization (particularily, of the wife) in order to limit family size at two or three children.

Long-Term Family Planning

Table VIII shows the probabilities of a couple employing a temporary method of birth control at the beginning of the process later entering the various transient states of the model. Together, the entries in the table may provide an indication of preferences in birth control methods at different stages of family formation. However, some of the entries (for example, those that denote the probabilities of a couple later being in its initial state) reflect in part short-term shifts between states.

While all couples of less than parity three are likely to resort to contraception with increasing parity, the choice of methods is related to current family planning behaviour. Nulliparous couples, regardless of their initial methods of birth control, gravitate

TABLE VIII

Probabilities that a Couple Currently in a Transient State (i)
Will Later Enter Other Transient States (j)

i \ j	1	2	3	5	6	7	9	10	11	14	15	16
1	0.51	0.17	0.47	0.09	0.25	0.27	0.11	0.25	0.38	0.04	0.09	0.51
2	0.21	0.38	0.41	0.11	0.45	0.28	0.08	0.28	0.37	0.04	0.10	0.05
3	0.10	0.06	0.44	0.06	0.17	0.33	0.09	0.25	0.47	0.04	0.09	0.06
5	0.0	0.0	0.0	0.52	0.32	0.36	0.12	0.28	0.26	0.04	0.09	0.04
6	0.0	0.0	0.0	0.09	0.22	0.13	0.06	0.36	0.24	0.04	0.13	0.04
7	0.0	0.0	0.0	0.13	0.22	0.52	0.09	0.21	0.40	0.04	0.08	0.05
9	0.0	0.0	0.0	0.0	0.0	0.0	0.54	0.22	0.17	0.20	0.14	0.05
10	0.0	0.0	0.0	0.0	0.0	0.0	0.07	0.63	0.01	0.08	0.18	0.02
11	0.0	0.0	0.0	0.0	0.0	0.0	0.12	0.26	0.63	0.06	0.12	0.12
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.74	0.13	0.15
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.01	0.70	0.07
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.16	0.22	0.71

toward the pill at parities zero and two. Whereas nulliparous non- and oral contraceptors are equally divided between the pill and other temporary contraceptive measures if they reach parity one, nulliparous couples initially employing other temporary contraceptives are most likely to continue using those methods if they bear a child. Among currently uniparous couples, non-contraceptors are equally likely to employ either the pill or other temporary methods if they attain parity two, while those already employing a temporary method will tend to favour their current techniques at the next parity level.

It is apparent that couples initially observed at parities zero, one and two will tend to employ temporary contraceptive methods other than the pill if they reach parity three or above. But, the low probabilities of these couples ever employing a temporary method at this level suggest that many will not attain parity three and that, if they do, they will adopt a permanent means of fertility control shortly after the third birth.

The total number of transient states entered by a couple before it adopts contraceptive sterilization or the wife reaches the end of her fecund span is shown in Table IX. For nulliparous oral contraceptors and couples initially using other temporary contraceptive techniques at parity one and above, the relatively low numbers of transient states entered may reflect either satisfaction with their current family planning methods or shorter times till absorption (see also Table XII). These estimates, as well as those contained in Table VIII, would invariably be low, however, since the transition matrix does not capture all movements between states, parities three

TABLE IX

Total Numbers of Transient States Entered before Absorption by Couples Starting in Transient States

Parity	Use-Parity State*	Number of States Entered
	1	3.1
0	2	3.4
	3	2.7
	5	2.5
1	6	2.1
	7	2.2
	9	1.8
2	10	1.4
	11	1.7
	14	1.3
3+	15	1.1
	16	1.4

* See text for explanation of codes for states

and above have been collapsed and "other" methods categories subsume a variety of contraceptive techniques.

Table X shows the average times couples starting in each transient state will stay in the different transient states before ultimately being absorbed. The associated standard deviations are contained in Table XI. Thus, a nulliparous couple initially using no contraception can be expected to remain in that state for 4.1 years on the average; it would be expected to employ oral contraceptives for approximately 1.7 years; etc.

The comparatively large elements contituting the main diagonal of Table X reflect the fact that many couples remain in their initial states for considerable lengths of time. The relatively low values of the off-diagonal entries suggest that once having left their initial states, couples move rapidly between temporary methods of birth control and to higher parity levels. As was the case for the expected durations shown in Table VI, however, the standard deviation of each of these quantities indicates that large variations occur among individual couples with respect to the timing of family planning. Part of the variation may also be due, of course, to differences in the ages and fecundity of the couples initially in the various transient states.

For the initially nulliparous, the average times spent using no contraception generally decline in favour of temporary contraception as higher parities are reached. Non- and oral contraceptors, after leaving their initial states, have relatively greater success with the pill than with other temporary contraceptive methods at higher parity

TABLE X

Expected Numbers of Years Spent in Different Transient States (j)
by Couples Starting in Transient States (i)

i \ j	1	2	3	5	6	7	9	10	11	14	15	16
1	4.1	0.5	1.7	0.4	0.6	1.1	0.5	1.3	2.1	0.3	0.6	0.4
2	0.9	3.2	1.5	0.4	1.2	1.2	0.4	1.5	2.0	0.3	0.6	0.3
3	0.4	0.2	3.6	0.2	0.4	1.4	0.4	1.4	2.5	0.3	0.6	0.4
5	0.0	0.0	0.0	4.1	0.8	1.5	0.5	1.5	1.4	0.3	0.6	0.3
6	0.0	0.0	0.0	0.4	2.6	0.5	0.2	2.0	1.3	0.3	0.9	0.3
7	0.0	0.0	0.0	0.5	0.6	4.2	0.4	1.1	2.1	0.3	0.5	0.4
9	0.0	0.0	0.0	0.0	0.0	0.0	4.3	1.2	0.9	1.5	0.9	0.4
10	0.0	0.0	0.0	0.0	0.0	0.0	0.3	5.5	0.1	0.6	1.1	0.2
11	0.0	0.0	0.0	0.0	0.0	0.0	0.5	1.4	5.4	0.4	0.7	0.8
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.6	0.8	1.0
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	6.4	0.5
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	1.4	6.9

TABLE XI

Standard Deviations of Expected Years Spent in Different Transient States (j) by Couples Starting in Transient States (i)

i \ j	1	2	3	5	6	7	9	10	11	14	15	16
1	2.9	1.5	2.4	1.5	1.3	2.4	1.7	3.2	3.7	2.1	2.4	2.0
2	2.2	2.0	2.3	1.6	1.5	2.5	1.5	3.3	3.7	2.0	2.6	2.0
3	1.5	0.9	2.4	1.2	1.1	2.6	1.6	3.2	4.0	2.0	2.4	2.2
5	0.0	0.0	0.0	3.0	1.3	2.7	1.8	3.3	3.2	2.1	2.4	1.8
6	0.0	0.0	0.0	1.5	1.2	1.8	1.2	3.7	3.1	2.0	2.9	1.8
7	0.0	0.0	0.0	1.8	1.2	3.0	1.5	3.0	3.8	1.9	2.3	2.0
9	0.0	0.0	0.0	0.0	0.0	0.0	3.2	3.0	2.7	4.2	3.0	2.1
10	0.0	0.0	0.0	0.0	0.0	0.0	1.3	4.3	0.7	2.8	3.3	1.4
11	0.0	0.0	0.0	0.0	0.0	0.0	1.8	3.3	4.3	2.3	2.7	3.0
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.5	2.9	3.3
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	5.3	2.3
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.9	3.7	5.9

levels. Those initially employing other temporary methods show similar times for these techniques and the pill at parity one but a longer duration of use for the pill at parity two. Among all initially nulliparous couples, the expected times spent at different parities vary markedly from one level to the next. Thus, whereas a couple can expect to remain childless for a period ranging from five to six years, average times spent at parities one and two are approximately two and four years respectively.

Although all couples employing temporary methods at parities one and above at the beginning of the process show declines in the average numbers of years spent at successive parity levels, there are no clear patterns in the durations of use for particular methods. However, a general pattern is discernable among couples of the same initial family size: non- and oral contraceptors have similar lengths of stay within each parity level while couples initially employing temporary methods other than the pill tend to move through parity levels at a somewhat faster rate.

This pattern is reflected in the expected times till absorption for couples starting in the different transient states. These times, with their standard deviations, are shown in Table XII. Amongst the nulliparous, the relatively low value for oral contraceptors suggests that these couples may be forming their families quickly and then resorting to sterilization to curtail further births. Similar average times till absorption for non- and oral contraceptors initially at parities one and above, as well as the previously noted similar stays within specific parity levels, result mainly from non-users switching

TABLE XII

Expected Times until Absorption, with Associated Standard Deviations, for Couples Starting in Transient States

Parity	Use-Parity State*	Expected Time (years)	Standard Deviation (years)
0	1	13.6	9.2
	2	13.5	8.8
	3	11.8	8.7
1	5	11.1	8.3
	6	8.4	7.5
	7	10.0	8.2
2	9	9.3	7.8
	10	7.7	6.8
	11	9.4	7.8
3+	14	9.5	8.2
	15	7.0	6.1
	16	9.6	8.1

* See text for explanation of codes for states

to the pill. These similarities may also be a reflection of the sub-fecundity of some non-contracepting women. Comparatively short times till absorption for couples initially employing other temporary contraceptive methods may be an indication of the relative ineffectiveness of most of these techniques vis-à-vis oral anovulents. Although use of relatively unreliable methods probably reflects lack of concern with the timing and spacing of births, it need not entail lack of concern with completed family size.

Table XIII shows the probabilities that couples initially in transient states of the model will ultimately enter the various absorbing states. The fact that tubal ligation and hysterectomy are favoured over vascectomy by a large margin is not surprising given the sex differentials in contraceptive sterilizations presently observed in Edmonton (see Table IV, Chapter II). However, the extent to which couples will adopt sterilization to achieve small family sizes is startling. Two out or three initially nulli- and uni-parous couples might be expected to elect sterilization before the birth of a third child, while the vast majority of the remainder will opt for the operation after a third or higher order birth. In general, couples with two or more children at the beginning of the process have even higher probabilities of adopting sterilization at their initial or a subsequent parity. Nevertheless, those initially using temporary contraceptive methods other than the pill do show noticeably greater likelihoods of going to the end of the wife's fecund span. Such couples are either bearing large families, either through design or because they are inefficient contraceptors, or the wives are

TABLE XIII

Probabilities that a Couple Starting in a Transient State (i) Will Enter Different Absorbing States (j)

i \ j	4	8	12	13	17	18	19
1	.05	.17	.15	.29	.09	.15	.10
2	.01	.17	.16	.31	.09	.17	.09
3	.02	.12	.17	.33	.09	.15	.12
5	0.0	.21	.18	.31	.09	.15	.06
6	0.0	.13	.15	.33	.10	.21	.07
7	0.0	.16	.25	.31	.08	.13	.07
9	0.0	0.0	.05	.36	.18	.31	.09
10	0.0	0.0	.10	.32	.19	.25	.14
11	0.0	0.0	.20	.39	.14	.21	.06
14	0.0	0.0	0.0	0.0	.25	.71	.04
15	0.0	0.0	0.0	0.0	.22	.54	.24
16	0.0	0.0	0.0	0.0	.28	.62	.10

exposed to low risks of pregnancy. Taken overall, the results reported in the table suggest that despite variations in their strategies of family planning, in terms of birth control methods used and timing and spacing of births, the pressure for couples to curtail fertility permanently increases dramatically as their family sizes approach a perceived optimal upper limit.

Throughout the analysis in this chapter, family planning has been examined irrespective of the actual distributions of couples in the states of the model over time. Although patterns of family planning have been seen to vary according to couples' initial states, this might lead to a somewhat distorted view of the overall process. For example, whereas nulliparous couples initially employing temporary birth control methods other than the pill show patterns of family planning that are significantly different from those of nulliparous couples generally, the former account for but a small proportion of the nulliparous. By applying equation (3) in Chapter III (and assuming, of course, that the transition matrix is stationary), the distributions of couples at selected times can be computed. These distributions are shown in Table XIV.

Starting from the (initial) distribution of 1972, the process reaches its limiting distribution in about thirty years. This corresponds approximately to the expected fecund years of a young woman who was just starting her married life at the beginning of the process. The time taken to reach the final distribution increases monotonically with parity, ranging from about 12 years for parity zero to 32 years for parities three and above. The small proportions of

TABLE XIV

Distributions of Couples among States of the Model at Selected Times

Year	States																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1972	.04	.02	.14	.02	.02	.03	.07	.02	.02	.07	.07	.02	.07	.02	.07	.04	.05	.14	.08
1976	.02	.01	.04	.02	.01	.02	.05	.04	.02	.06	.08	.05	.12	.02	.05	.03	.07	.19	.10
1980	.01	0.0	.01	.02	.01	.01	.03	.05	.01	.05	.06	.07	.16	.02	.04	.02	.09	.22	.12
1984	0.0	0.0	0.0	.02	0.0	0.0	.01	.06	.01	.03	.04	.09	.19	.01	.03	.02	.11	.25	.13
1988	0.0	0.0	0.0	.02	0.0	0.0	.01	.06	.01	.02	.02	.09	.20	.01	.02	.01	.12	.27	.14
1992	0.0	0.0	0.0	.02	0.0	0.0	0.0	.06	0.0	.01	.01	.10	.21	.01	.01	.01	.12	.28	.14
1996	0.0	0.0	0.0	.02	0.0	0.0	0.0	.06	0.0	.01	.01	.10	.22	.01	.01	.01	.13	.29	.14
2000	0.0	0.0	0.0	.02	0.0	0.0	0.0	.06	0.0	0.0	0.0	.10	.22	0.0	0.0	0.0	.13	.30	.14

couples opting for the sterilization of either partner at parities zero and one suggests that the operation is mainly performed at these levels to safeguard the health of the wife. Over time, the proportions of multiparous couples employing temporary family planning methods generally decline in favour of contraceptive sterilizations. The rapidity with which the final distribution is approached indicates that many couples, after delaying the birth of their first child, go on to form small families (ie. two or three children) quickly. The increasing importance of sterilization as the means by which small family size will be achieved is indicated by the small proportions of initially fecund women actually reaching the natural end of the childbearing span.

CHAPTER V

IMPLICATIONS OF THE STUDY

Limitations of the Study

The stochastic model employed in this study merely provides a first approximation of the family planning behaviour of Edmonton couples. Restrictions imposed by the small sample size and the conceptualization of family planning as an absorbing Markov chain lead to a number of shortcomings in the analysis.

In the first place, couples have been treated without regard for their actual inclinations or differential abilities to control fertility at different stages of the family cycle. Although use of effective contraception has been seen to be widespread in Edmonton, a minority, whether through a lack of reliable contraceptive knowledge or a desire for large families, may in reality have patterns of family formation very different from those of "representative" Edmonton couples. Indeed, this might explain in part the large variations encountered in the expected durations of use for the different temporary methods of birth control. This problem might be circumvented by stratifying couples in terms of their desired family sizes and then undertaking separate analyses on the resulting subsets of the married population. A similar procedure could also be employed to lessen the possible effects of disparate ages of couples initially in each state of the model.

The family planning process is intuitively non-Markovian. The process has been made Markovian by increasing the state space so

as to include several parity levels. Despite this, however, the basic process may still be non-Markovian as some parities and contraceptive methods have been lumped. In such a case, the non-Markovian process could possibly be made Markovian by further expanding the state space of the model.

In the introduction to finite Markov chains in Chapter III, all couples currently in a state were assumed to be subject to identical probabilities of moving to the various states of the model at the next step of the process. The assumption that couples currently in the same state of the model are homogeneous with respect to the transition probabilities is not entirely realistic. A better appreciation of family planning dynamics could be obtained if the parameters, p_{ij}'s, were allowed to vary from one couple to another so as to allow for the possibility of differences in fecundity, motivations to regulate fertility and the efficiency with which contraception is practiced. A modification, which would allow for the heterogeneity of couples with respect to the transition probabilities, could be introduced if a probability distribution were specified for each of these parameters and a mixing distribution employed to obtain inferences about the behaviour of a typical couple.

A further problem arises when the transition matrix is estimated from cross-sectional data; viz., couples that have recently moved to a state are treated in a similar fashion to those that have been in that state for some time. Movements between states may depend in part on the time already spent in the current state. This possibility could be taken into account if family planning were

formulated as a semi-Markov, or Markov renewal, process. In such a model, the time a couple spends in a state would be assumed to be a random variable distributed accorded to a given function. Once the couple moves, however, the conditional probabilities of shifting from the current to other states would be governed by a typical transition matrix similar to the one in Chapter IV.

Summary of Findings

In Chapter II, an examination of the family planning behaviour of Edmonton couples that were presumably exposed to the risk of child-bearing revealed that socio-economic factors, such as ethnicity, income and occupation, have little or no direct effect on the extent of current contraceptive use. Use of contraception, though widespread, does show a strong relation to the stage of family formation a couple has reached. This is especially true for the two most widely used techniques - oral anovulents and contraceptive sterilization - where an overwhelming popularity of the pill among the nulli- and uni-parous declines sharply in favour of sterilization among couples at parities two and above.

The absorbing Markov chain model employed in the last chapter provides an indication of the expected long-term family planning of Edmonton couples if the patterns observed in the recent past were to continue unchanged. Whereas the majority of fecund couples at all parity levels would be expected to continue employing temporary contraception systematically to regulate fertility, individual variations in both use of temporary birth control and the timing and spacing of pregnancies are pronounced. Despite diverse strategies of family

formation, however, most couples would ultimately adopt sterilization to achieve the goal of small completed family size.

Implications for Family Planning

The findings of this study are consistent with the low rate of natural increase currently being experienced by the Canadian population. In Edmonton, the mechanism through which low fertility is being achieved at present and may continue to be achieved in the future is the widespread use of efficient temporary contraception at the lower parities with shifts to permanent methods of birth control after several children have been borne. Although few couples appear to be totally ignorant of contraceptive techniques, differences in the extent of contraceptive knowledge may persist - particularly among newly-married couples. Over time, however, either the efficacy of the educational process before marriage or the family planning experience during marriage apparently increases the awareness of the majority of people about effective means of fertility control.

Not all aspects of reproductive behaviour have been examined. Given uncertainties in isolating the population at risk as well as the questionable "planned" status of illegitimate births, this study has been confined to fertility and fertility control occurring within *de jure* and *de facto* marriages. Additionally, the possibility of marriage dissolution through death or divorce has not been taken into account.

Nevertheless, the results of the study could have important implications for prediction of the future family-building of Edmonton couples. The time-homogeneous model employed here assumes *a fortiori*,

however, that no shifts will occur in patterns of contraceptive use. Yet, use of efficient temporary contraceptive techniques does not preclude the possibility that young couples are deferring births rather than limiting completed family size. Were this true, shifts from contraception, in turn entailing changes in the timing of births, combined with rapid family formation by members of new marriage cohorts could result in comparatively large birth cohorts in the near future. Or, even if the small family norm continues, concern for the safety of the pill, leading many couples to adopt relatively unreliable temporary methods of birth control, could result in either unwanted children or increased demands for abortion.

BIBLIOGRAPHY

Allingham, J. D., T. R. Balakrishnan and J. F. Kantner
1969 "Time series growth in use of oral contraception and the differential diffusion of oral anovulents", Population Studies 23(1).

_____.
1970 "The end of the rapid increase in the use of oral anovulents? Some problems in the interpretation of time series of oral use among married women", Demography 7(1).

Balakrishnan, T. R., J. D. Allingham and J. F. Kantner
1970 "Analysis of oral contraceptive use through multiple decrement life table techniques", Demography 7(4).

Balakrishnan, T. R., J. F. Kantner and J. D. Allingham
1975 Fertility and Family Planning in a Canadian Metropolis. Montreal: McGill-Queen's University Press.

Bartholomew, D. G.
1973 Stochastic Models for Social Processes. London: John Wiley and Sons, Inc.

Bartos, O. J.
1967 Simple Models of Group Behaviour. New York: Columbia University Press.

Beaujot, R. P.
1975 Ethnic Fertility Differentials in Edmonton. Ph. D. Dissertation, The University of Alberta.

Beaman, J. and R. McGinnis
1974 "Modelling out-migration from cities to allow parameter estimation and related hypothesis testing", Paper presented at the Annual Meetings of the Canadian Sociology and Anthropology Association, Toronto.

Bishop, Y. M. M., S. E. Fienberg and P. W. Holland
1975 Discrete Multivariate Analysis: Theory and Practice. Boston: M. I. T. Press.

Bogue, D.
1969 Principles of Demography. New York: John Wiley and Sons, Inc.

Bumpass, L. L. and C. F. Westoff
1970 The Later Years of Childbearing. Princeton: Princeton University Press.

Chiang, C. L.
1968 Introduction to Stochastic Processes in Biostatistics. New York: John Wiley and Sons, Inc.

Cho, L., W. H. Grabill and D. Bogue
1979 Differential Current Fertility in the United States. Chicago: University of Chicago Press.

Ebanks, G. E.
1970 "Users and non-users of contraception: tests of stationarity applied to members of a family planning programme", Population Studies 24(1).

Feller, W.
1957 An Introduction to Probability Theory and Its Applications, Vol. I. New York: John Wiley and Sons, Inc.

Freedman, R., P. K. Whelpton and A. A. Campbell
1959 Family Planning, Sterility, and Population Growth. New York: McGraw-Hill Book Company, Inc.

Grabill, W. H., C. F. Kiser and P. K. Whelpton
1958 The Fertility of American Women. New York: John Wiley and Sons, Inc.

Green, S.
1971 The Curious History of Contraception. London: Ebury Press.

Grindstaff, C. F. and G. E. Ebanks
1971 "Vascectomy as a birth control method", Grindstaff, C. F., C. L. Boydell and P. C. Whitehead (eds.), Population Issues in Canada. Toronto: Holt, Rinehart and Winston of Canada, Ltd.

Hawthorn, G.
1970 The Sociology of Fertility. Toronto: Collier-Macmillan Ltd.

Henripin, J. and E. Lapierre-Adamcyk
1974 La Fin de la revanche des berceaux: Qu'en pensent les Québecoises?. Montréal: Les Presses de l'Université de Montréal.

Himes, N.
1963 Medical History of Contraception. New York: Gamut Press.

Kelly, A., S. Jolles, J. Vobecky and L. Munan
1972 "Quelques considérations sur le sondage dans la recherche épidémiologique, avec une note sur la fertilité", L'Union Medicale du Canada 101.

Kemeny, J. G. and J. L. Snell
1963 Finite Markov Chains. New York: Van Nostrand Reinhold Co.

Kiser, C. V. and P. K. Whelpton
1958 "Social and psychological factors affecting fertility: summary of chief findings and implications for future studies", Milbank Memorial Fund Quarterly 36(3).

Kiser, C. V., W. H. Grabill and A. A. Campbell
1968 Trends and Variations in Fertility in the United States. Cambridge, Mass.: Harvard University Press.

Krishnan, P. and A. Sangadasa
1975 "Stochastic indicators of occupational mobility, Canada: 1951-1961", Social Indicators 1.

Lewotin, R. C. and J. Felsenstein
1965 "The robustness of homogeneity tests in 2xn tables", Biometrics 21.

Lorimer, F.
1954 Culture and Human Fertility. Paris: UNESCO.

Okraku, I. O.
1972 "Fishing and fertility: study of a Nova Scotia fishing village", Paper presented at the Annual Meetings of the Canadian Sociology and Anthropology Association, Montreal.

Pool, J. E.
1975 "Female Reproductive Behaviour", Unpublished manuscript, The University of Ottawa.

Pool, J. E., L. Marret and J. Last
1973 "A survey of female health and reproductive behaviour in Ottawa", Paper presented at the Annual Meeting of the Canadian Association of Teachers of Social and Preventive Medicine, Calgary.

Rainwater, L.
1960 And the Poor Get Children. Chicago: Quadrangle Books, Inc.

———.
1965 Family Design: Marital Sexuality, Family Size and Contraception. Chicago: Aldine.

Rindfuss, R. and C. F. Westoff
1974 "The initiation of contraception", Demography 11(1).

Ryder, N. B. and C. F. Westoff
1971 Reproduction in the United States: 1965. Princeton: Princeton University Press.

Simmons, A. B. and J. E. Turner
1974 "The socialization of sex-roles and fertility ideals: a study of two generations in Toronto", Paper presented at the Annual Meeting of the Canadian Sociology and Anthropology Association, Toronto.

Stone, L. O.
1974 "Guaranteed annual income and mobility: a case for demometric analysis", Paper presented at the Annual Meetings of the Canadian Sociology and Anthropology Association, Toronto.

Tripathi, S. K. and P. Krishnan
1974 "A stochastic model of urbanization", Paper presented at the Annual Meetings of the Statistical Science Association of Canada, Toronto.

Weisbord, R. G.
1973 "Birth control and the black Americans", Demography 10(4).

Westoff, C. F., L. F. Herrera and P. K. Whelpton
1958 "The use effectiveness and acceptability of methods of fertility control", Milbank Memorial Fund Quarterly 36(3).

Westoff, C. F., R. G. Potter, P. C. Sagi and E. G. Mishler
1961 Family Growth in Metropolitan America. Princeton: Princeton University Press.

Westoff, C. F., R. G. Potter and P. C. Sagi
1963 The Third Child. Princeton: Princeton University Press.

Whelpton, P. K., A. A. Campbell and J. E. Patterson
1966 Fertility and Family Planning in the United States. Princeton: Princeton University Press.

Wilson, F. D. and L. L. Bumpass
1973 "The prediction of fertility among Catholics: a longitudinal analysis", Demography 10(4).